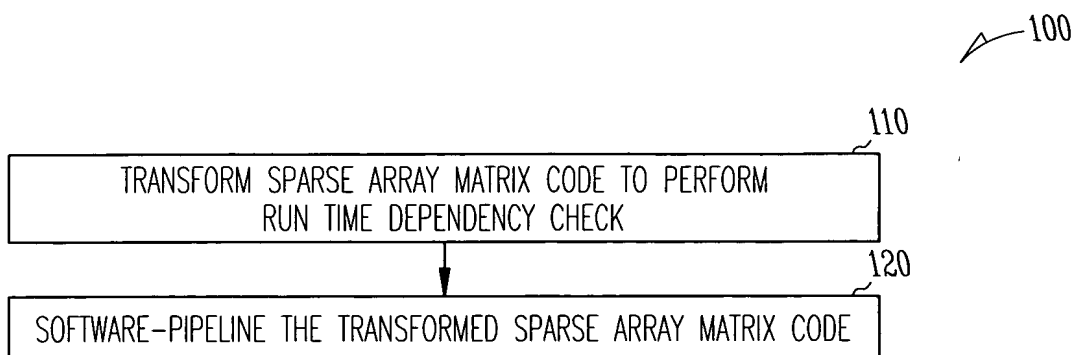TITLE: SYSTEM AND METHOD FOR SOFTWARE-PIPELINING OF LOOPS WITH SPARSE MATRIX ROUTINES
INVENTORS NAME: Kalyan Muthukumar et al.
SERIAL NO.: 10/612724

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_~100_

110

| TRANSFORM SPARSE ARRAY MATRIX CODE TO PERFORM RUN TIME DEPENDENCY CHECK |

120

| SOFTWARE-PIPELINE THE TRANSFORMED SPARSE ARRAY MATRIX CODE |

Fig. 1

_~200_

210

| FORM A PREDETERMINED NUMBER OF VARIABLES BASED ON A VIRTUAL UNROLLING FACTOR M |

220

| INITIALIZE THE FORMED PREDETERMINED NUMBER OF VARIABLES BY CREATING VARIABLES $b0$, $b1$, ... $bM-1$ AND $a0$, $a1$, ... $a M-1$ AND INITIALIZING $b0$, $b1$, ... $bM-1$ TO AN ILLEGAL VALUE FOR THE b ARRAY, SAY TO -1 |

230

| LOAD PRIOR COMPUTED VALUES SUCH THAT $b[i]$ IS LOADED INTO THE VARIABLE bM AND THE VALUE OF $c[i]$ IS LOADED INTO THE VARIABLE cM |

240

| ASSIGN THE PRIOR COMPUTED VALUES, INSIDE THE LOOP BODY, TO A PREDETERMINED NUMBER OF REGISTERS |

Fig. 2

TITLE: SYSTEM AND METHOD FOR SOFTWARE-PIPELINING OF LOOPS WITH SPARSE MATRIX ROUTINES
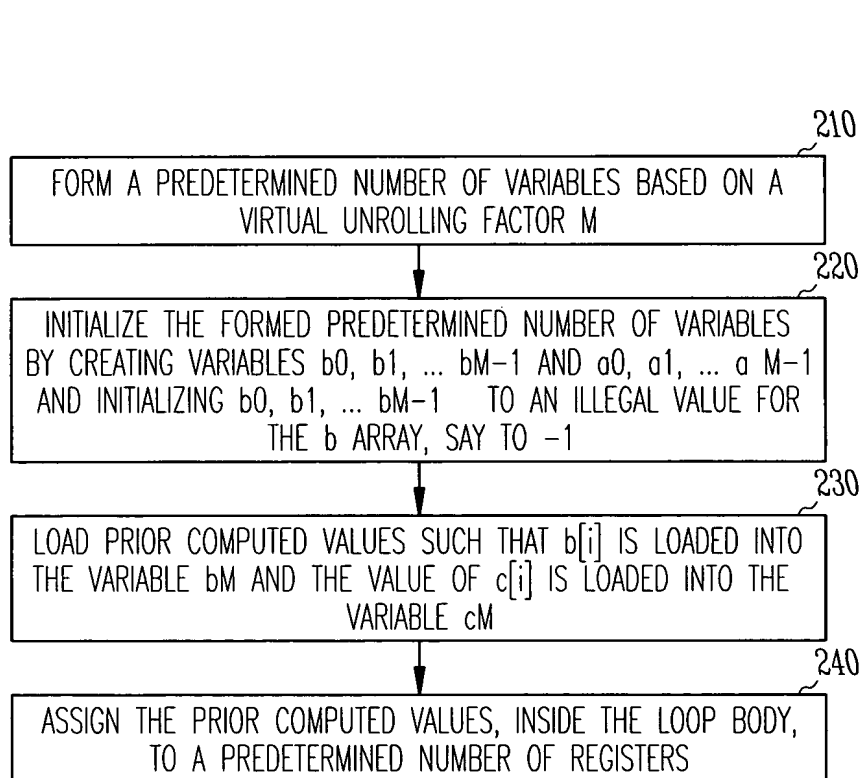INVENTORS NAME: Kalyan Muthukumar et al.
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/—300

310

```
UNPIPELINED (17 CYCLES PER ITERATION)
TIME - > 012345678901234567890123456789012345678890123456789012345 6789
ITER01:  L--------A-------S
ITER02:             L--------A-------S
ITER03:                        L--------A-------S
ITER04:                                   L----.....
```

320

```
UNROLLED (9 CYLES PER ITERATION)
TIME >   012345678901234567890123456789012345678890123456789012345 6789
ITER01:  L--------A-------S
ITER02:     L--------A-------S
ITER03:        L--------A-------S
ITER04:                  L--------A-------S
ITER05:                     L--------A-------S
ITER06:                        L--------A-------S
```

330

```
SOFTWARE PIPELINED (5 CYLES PER ITERATION)
TIME->   012345678901234567890123456789012345678890123456789012345 6789
ITER01:  L--------A-------S
ITER02:     L--------A-------S
ITER03:        L--------A-------S
ITER04:           L--------A-------S
ITER05:              L--------A-------S
ITER06:                 L--------A-------S
```
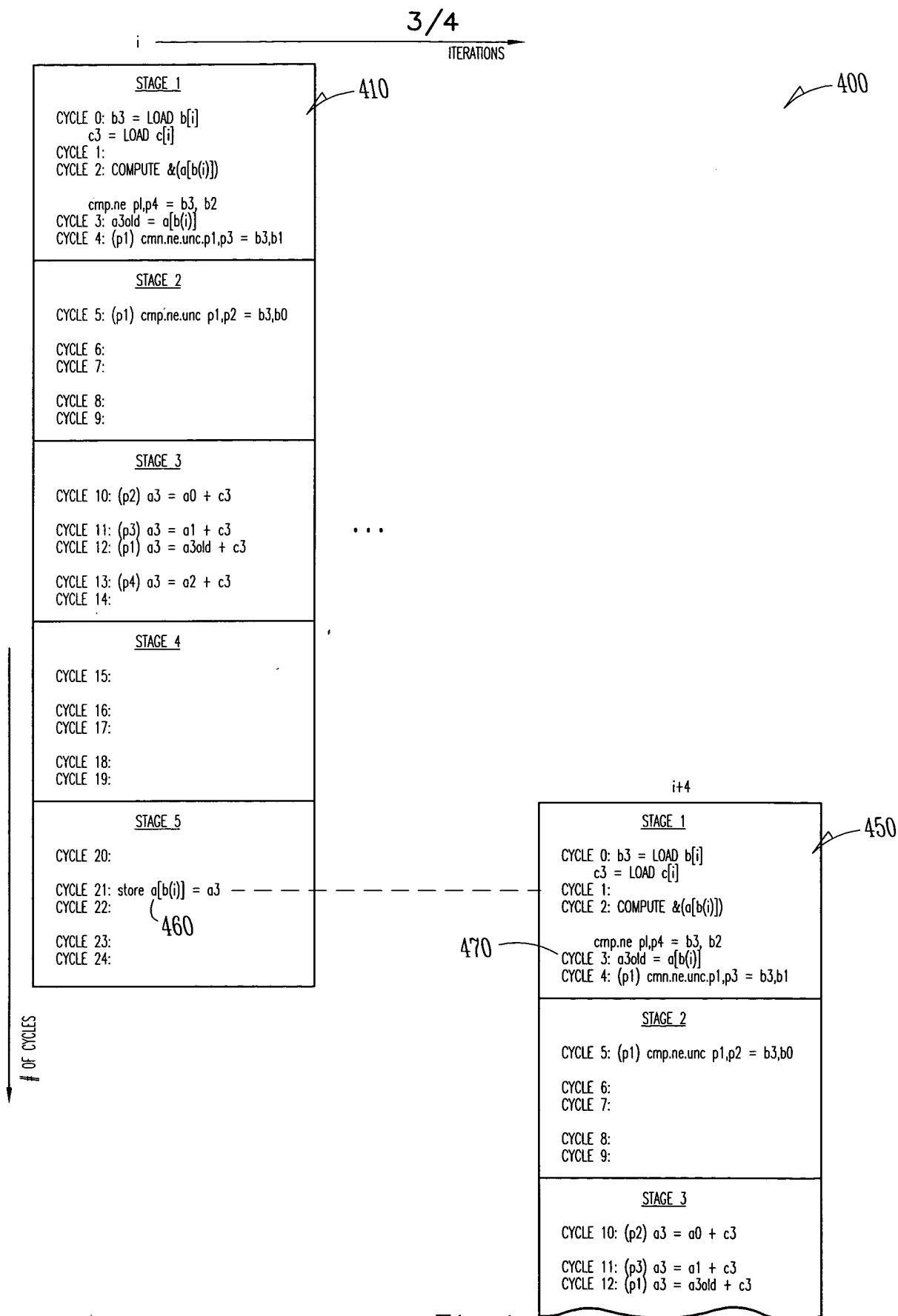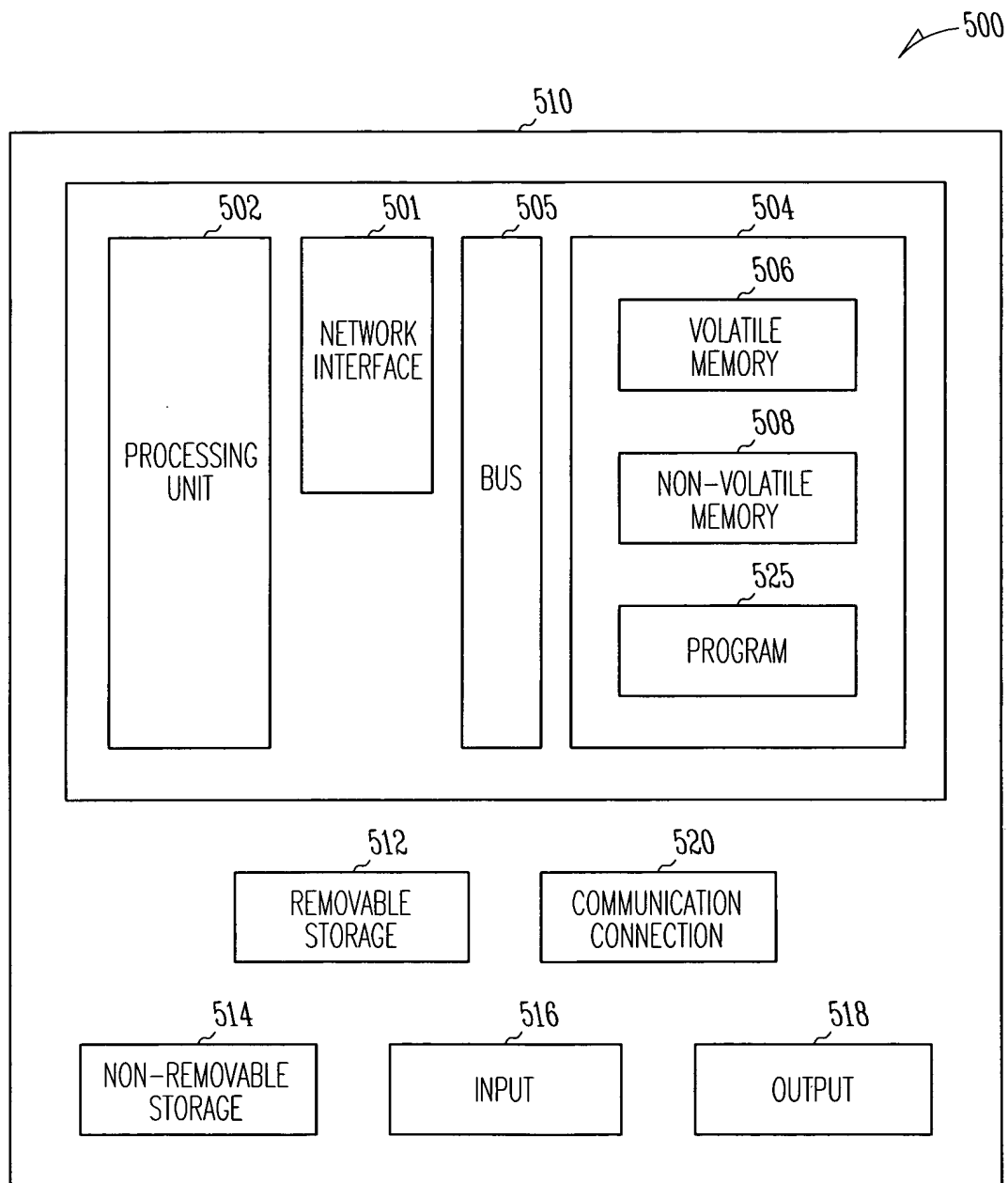
Fig.3

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INVENTORS NAME: Kalyan Muthukumar et al.
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i ———————————————————————→
ITERATIONS

— 410   ⟋— 400

STAGE 1

CYCLE 0: b3 = LOAD b[i]
　　　　 c3 = LOAD c[i]
CYCLE 1:
CYCLE 2: COMPUTE &(a[b(i)])

　　cmp.ne p1,p4 = b3, b2
CYCLE 3: a3old = a[b(i)]
CYCLE 4: (p1) cmn.ne.unc.p1,p3 = b3,b1

STAGE 2

CYCLE 5: (p1) cmp.ne.unc p1,p2 = b3,b0

CYCLE 6:
CYCLE 7:

CYCLE 8:
CYCLE 9:

STAGE 3

CYCLE 10: (p2) a3 = a0 + c3

CYCLE 11: (p3) a3 = a1 + c3
CYCLE 12: (p1) a3 = a3old + c3

CYCLE 13: (p4) a3 = a2 + c3
CYCLE 14:

· · ·

STAGE 4

CYCLE 15:

CYCLE 16:
CYCLE 17:

CYCLE 18:
CYCLE 19:

STAGE 5

CYCLE 20:

CYCLE 21: store a[b(i)] = a3 — — — — — —
CYCLE 22:
　　　　(—460
CYCLE 23:
CYCLE 24:

OF CYCLES

i+4

STAGE 1   ⟋— 450

CYCLE 0: b3 = LOAD b[i]
　　　　 c3 = LOAD c[i]
CYCLE 1:
CYCLE 2: COMPUTE &(a[b(i)])

470 —　　cmp.ne p1,p4 = b3, b2
CYCLE 3: a3old = a[b(i)]
CYCLE 4: (p1) cmn.ne.unc.p1,p3 = b3,b1

STAGE 2

CYCLE 5: (p1) cmp.ne.unc p1,p2 = b3,b0

CYCLE 6:
CYCLE 7:

CYCLE 8:
CYCLE 9:

STAGE 3

CYCLE 10: (p2) a3 = a0 + c3

CYCLE 11: (p3) a3 = a1 + c3
CYCLE 12: (p1) a3 = a3old + c3

Fig. 4

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Fig. 5